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Lecture	CS326 Agent Based Modelling & Simulation (G2)
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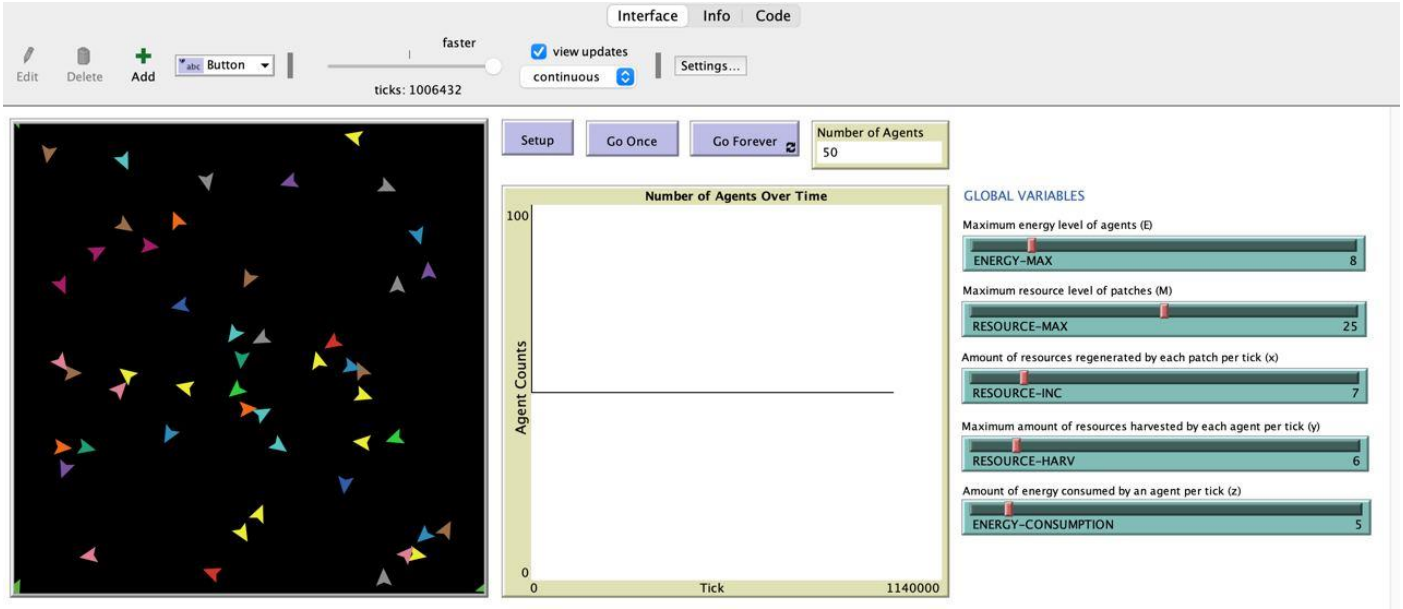
CS426 Assignment 1

Task 1-2

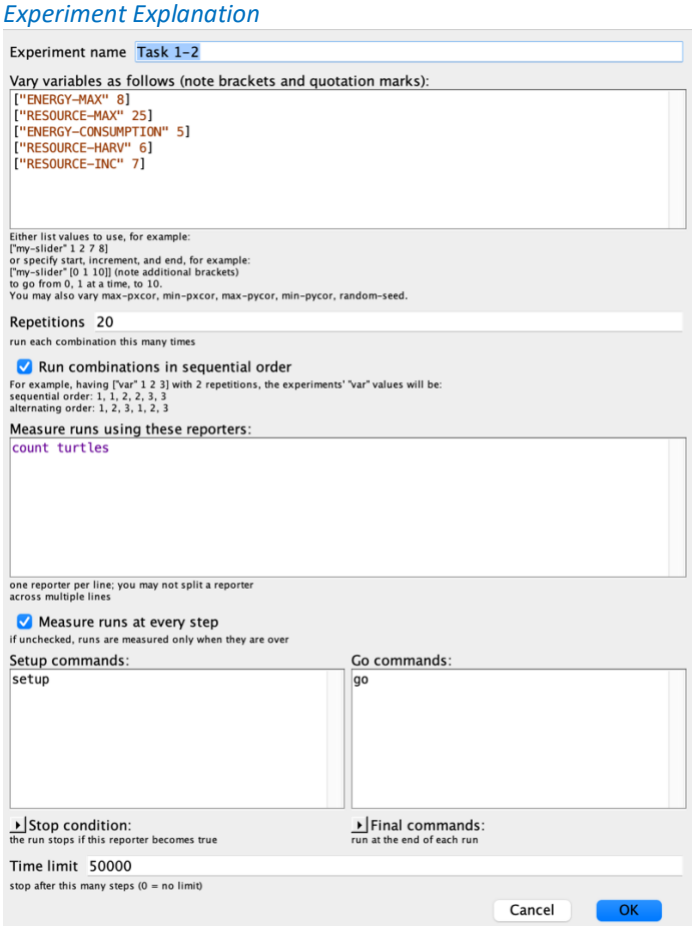
A few manual experiments were carried out to find a combination of parameters that results in the number of agents converging to around 50, one of such experiments is indicated as follows:



(Global variables is pre-configured for testing in "cskang.2020@scis.smu.edu.sg_A1 /task-1/model-6.nlogo")

As shown above, the number of agents *converges to 50 for around 1 million ticks*. After that, a more robust experiment is conducted using Netlogo's BehaviorSpace environment with the following settings:

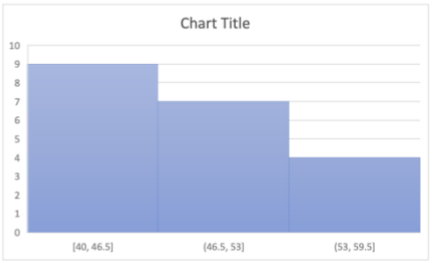
Experiment Explanation



1. The global variables setting is based on the result of first few manual experiments:
   - ENERGY-MAX : 8
   - RESOURCE-MAX : 25
   - RESOURCE-INC : 7
   - RESOURCE-HARV : 6
   - ENERGY-CONSUMPTION : 5
2. "Repetitions" is set to run 20 simulations on this setting (*sufficient rounds to ensure the conclusion is meaningful – as the average of 20 rounds will be used to draw the conclusion*).
3. "Time Limit" is set to 50,000 ticks to *ensure the agents start converging to a value*.
4. Below is the visualization of the result:

[run number]	ENERGY-MAX	RESOURCE-MAX	ENERGY-CONSUMPTION	RESOURCE-HARV	RESOURCE-INC	[step]	count turtles
1	8	25	5	6	7	50000	54
2	8	25	5	6	7	50000	50
3	8	25	5	6	7	50000	45
4	8	25	5	6	7	50000	55
5	8	25	5	6	7	50000	47
6	8	25	5	6	7	50000	46
7	8	25	5	6	7	50000	44
8	8	25	5	6	7	50000	57
9	8	25	5	6	7	50000	51
10	8	25	5	6	7	50000	48
11	8	25	5	6	7	50000	45
12	8	25	5	6	7	50000	45
13	8	25	5	6	7	50000	52
14	8	25	5	6	7	50000	46
15	8	25	5	6	7	50000	40
16	8	25	5	6	7	50000	41
17	8	25	5	6	7	50000	48
18	8	25	5	6	7	50000	57
19	8	25	5	6	7	50000	42
20	8	25	5	6	7	50000	50

Average Number of Turtles (50 Rounds)
48.15



(Refer "cskang.2020@scis.smu.edu.sg_A1 /task-1/model-6 Task 1-2-table.xlsx")

5. The result data is exported to an excel file for further processing:
   - Average number of turtles after convergence across 20 rounds is *48.15*.
   - The range of number of turtles after 50,000 ticks is *[40, 57]*.

Comment On the Impact of Each and Every Global Parameters On the Final Stable Number of Agents

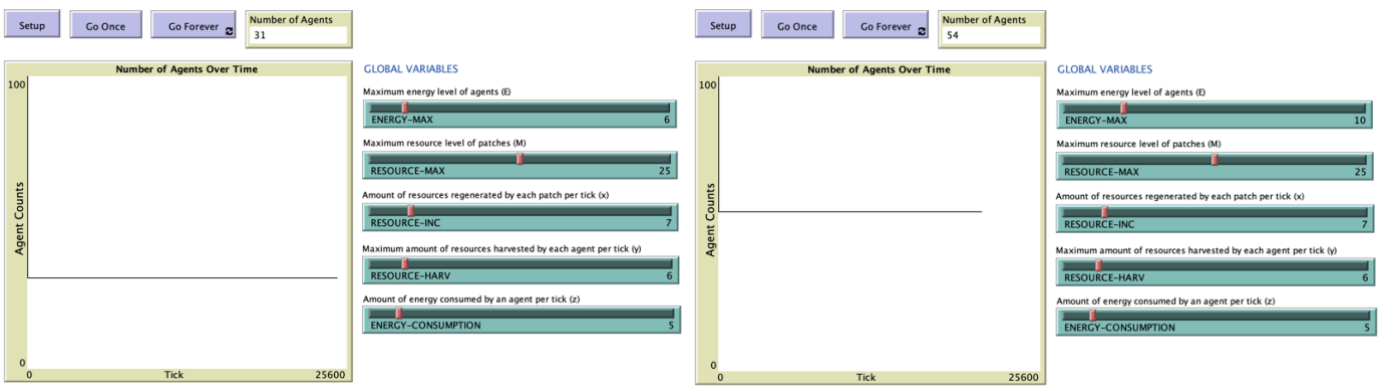
ENERGY-MAX (E)

1. ENERGY-MAX is set to 8 for convergence to 50 agents.
2. To observe the impact of ENERYGY-MAX, the values for other 4 global variables are kept the same and change the value of ENERGY-MAX, observe the differences in result:

Increasing ENERGY-MAX
- When ENERGY-MAX is increased from 8 to any values greater than 8, number of agents converge to a value of 50 (+- 10).

Decreasing ENERGY-MAX
- When ENERGY-MAX is decreased to 4 or below, number of agents converge to 0.
- When ENERGY-MAX is decreased to any values between 7 and 5, number of agents converge to some values below 50, depending on the degree of decrement of ENERGY-MAX.

Conclusion
- ENERGY-MAX affects the survival rate of each agent.
- Increasing ENERGY-MAX has little to no impact.
- Increment in ENERGY-MAX has relatively less impact (insensitive) to the model as compared to decrement in ENERGY-MAX.



    - 2 units of decrement leads to 31 (-19) agents left after convergence; 2 units of increment leads to 54 (+4) agents left after convergence.
- This implies below certain ENERGY-MAX threshold, although the value is not set to zero (e.g., 4), all agents tend to perish eventually as the energy store for each agent is too small and not sustainable over the long run.
- Greater amount of ENERGY-MAX allows agent more likely to:
    - Gain greater amount of initial energy
    - Store greater amount of energy
- Agents are less likely to starve when ENERGY-MAX increases as it can store more when the patch has sufficient resources, and vice versa.

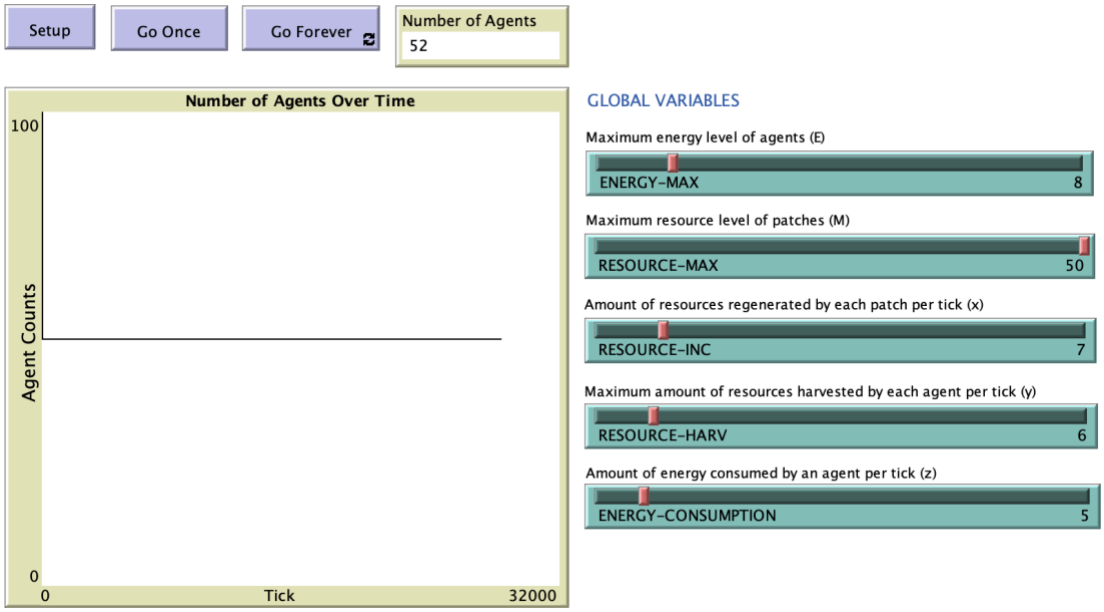
RESOURCE-MAX (M)

1. RESOURCE-MAX is set to 25 for convergence to 50 agents.
2. To observe the impact of RESOURCE-MAX, the values for other 4 global variables are kept the same and change the value of RESOURCE-MAX, observe the differences in result:

Increasing RESOURCE-MAX
- When RESOURCE-MAX is increased from 25 to any values greater than 25, number of agents converge to a value around 50 (+/- 10).

Decreasing RESOURCE-MAX
- When RESOURCE-MAX is decreased to 4 or below, number of agents converge to 0.
- When RESOURCE-MAX is decreased to any values between 24 and 5, number of agents converge to some values below 50, depending on the degree of decrement of RESOURCE-MAX.

Conclusion
- RESOURCE-MAX affects the survival rate of each agent.
- Increasing RESOURCE-MAX has little to no impact (very insensitive) under this setting.



    - 100% increment (25 to 50) leads to 52 (+2) agents left after convergence.
- Decreasing RESOURCE-MAX has negative impact as it introduces more competition between agents.
- Above certain RESOURCE-MAX threshold, (e.g., 25 or could be lower), increasing RESOURCE-MAX will not increase the survival rate of agents under this setting.
- However, increment in RESOURCE-MAX makes it takes longer for agents to perish, although the number of agents after convergence remain almost the same as patches are more likely to:
    - Gain greater amount of initial resources
    - Store greater amount of resources
- Initially, increment in agents are less likely to starve when RESOURCE-MAX increases as patches have higher chance to provide larger capacity of resources, but this effect vanishes eventually.

RESOURCE-INC (x)

1. RESOURCE-INC is set to 7 for convergence to 50 agents.
2. To observe the impact RESOURCE-INC, the values for other 4 global variables are kept the same and change the value of RESOURCE-INC, observe the differences in result:

Increasing RESOURCE-INC

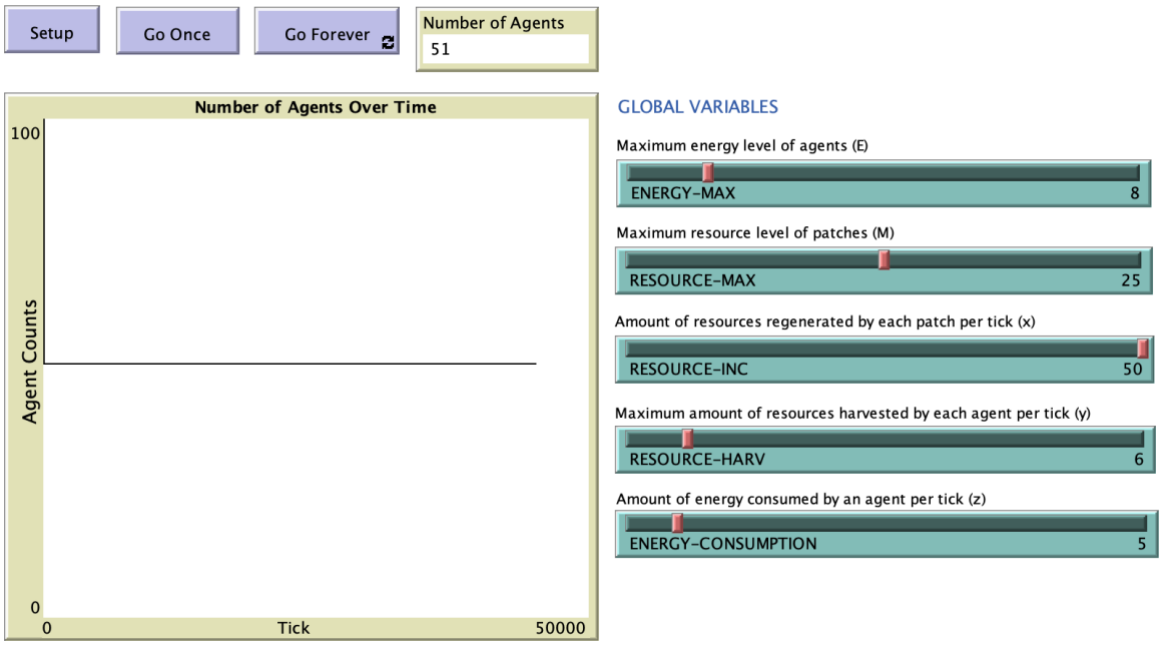
- When RESOURCE-INC is increased from 7 to any values greater than 7, number of agents converge to a value around 50 (+/- 10).

Decreasing RESOURCE-INC

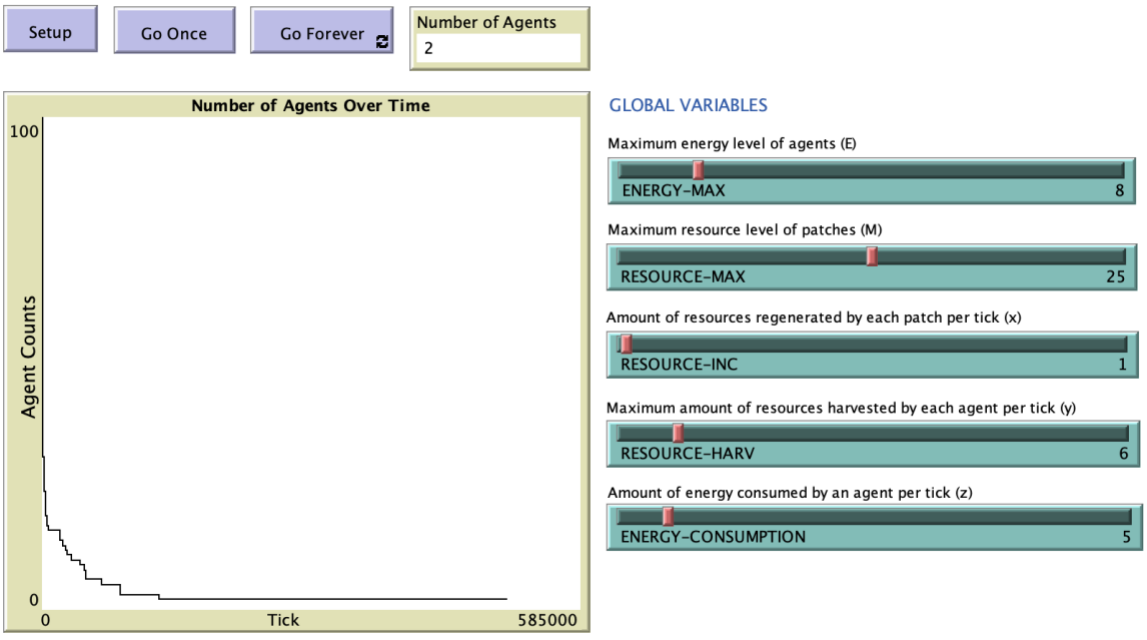
- When RESOURCE-INC is decreased to any values between 6 and 2, number of agents converge to a number below 50.

Conclusion

- RESOURCE-INC affects the survival rate of each agent as it defines the regeneration rate of resources at each patch.
- Like RESOURCE-MAX, increasing RESOURCE-INC has little to no impact (very insensitive) under this setting.



  - 700% increment (7 to 50) leads to 51 (+1) agents left after convergence
- Like RESOURCE-MAX, decreasing RESOURCE-INC has negative impact as it introduces more competition between agents.
- Unlike ENERGY-MAX and RESOURCE-MAX, as long as RESOURCE-INC is not set to 0, number of agents will not converge to 0 as the current setting instructs an agent to always move other patches to consume resources instead of staying on the current patch. At this point, most patches are resourceful, e.g.,



- Like RESOURCE-MAX, increment in RESOURCE-INC makes it takes longer for those agents to perish, as each patch now regenerates more resources.
- Agents are less likely to starve when RESOURCE-INC increases as patches can provide larger capacity of resources, but this effect vanishes eventually.

RESOURCE-HARV (y)

1. RESOURCE-HARV is set to 6 for convergence to 50 agents.
2. To observe the impact of RESOURCE-HARV, the values for other 4 global variables are kept the same and change the value of RESOURCE-HARV, observe the differences in result:

Increasing RESOURCE-HARV

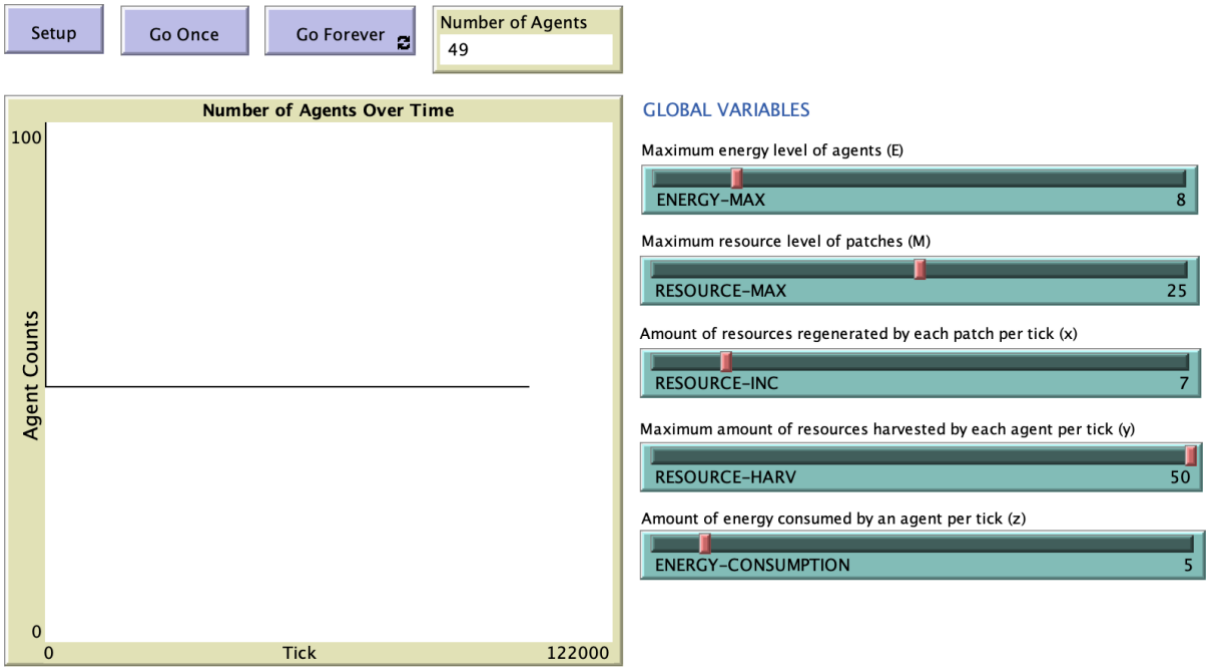
- When RESOURCE-HARV is increased from 6 to any values greater than 6, number of agents converge to a value around 50 (+/- 10).

Decreasing RESOURCE-HARV

- When RESOURCE-HARV is decreased to 4 or below, number of agents converge to 0.
- When RESOURCE-HARV is decreased to 5, number of agents converge to 50 (+/- 10).

Conclusion

- RESOURCE-HARV affects the survival rate of each agent as it defines the restoration rate of energy for each agent.
- Like RESOURCE-MAX, increasing RESOURCE-INC has little to no impact (very insensitive) under this setting.



  - 800% increment (6 to 50) leads to 49 (-1) agents left after convergence
- Like RESOURCE-MAX, increment in RESOURCE-HARV makes it takes longer for those agents to perish, as each agent now can harvest more resources at each patch.
- Agents are less likely to starve when RESOURCE-HARV increases as an agent can restore larger amount of energy, but this effect vanishes eventually.

ENERGY-CONSUMPTION (z)

1. ENERGY-CONSUMPTION is set to 5 for convergence to 50 agents.
2. To observe the impact of ENERGY-CONSUMPTION, the values for other 4 global variables are kept the same and change the value of ENERGY-CONSUMPTION, observe the differences in result:

Increasing ENERGY-CONSUMPTION

- When ENERGY-CONSUMPTION is increased from 5 to 6, number of agents converge to a value less than 50.
- When ENERGY-CONSUMPTION is increased from 5 to any values greater than or equal 7, number of agents converge to 0.

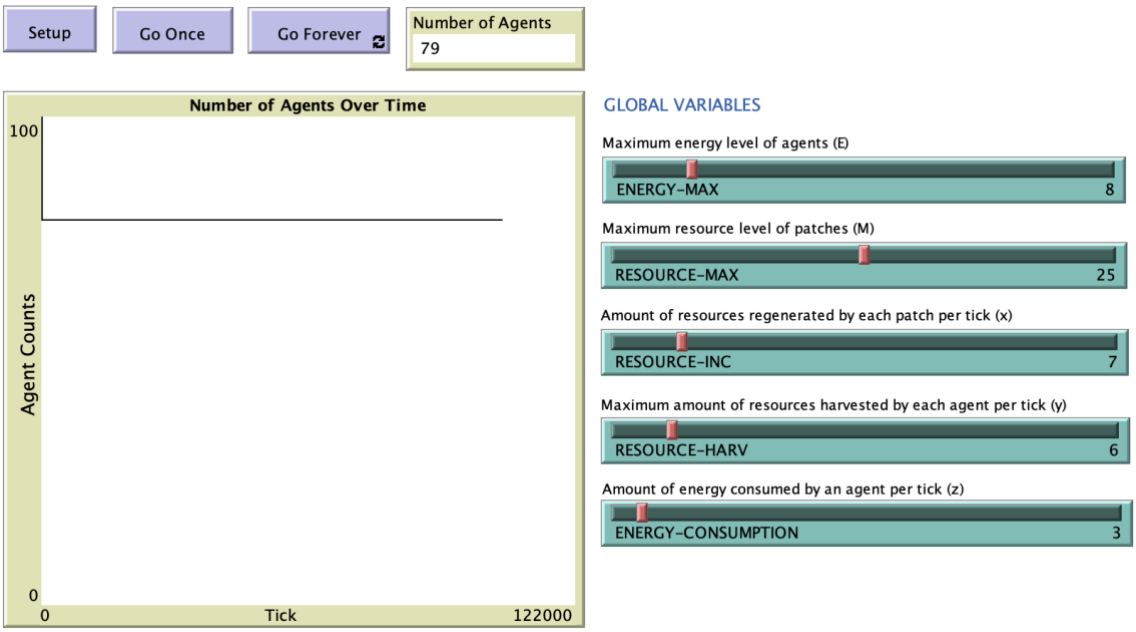
Decreasing ENERGY-CONSUMPTION

- When ENERGY-CONSUMPTION is decreased from 5 to any values smaller than 5, number of agents converge to a value more than 50.

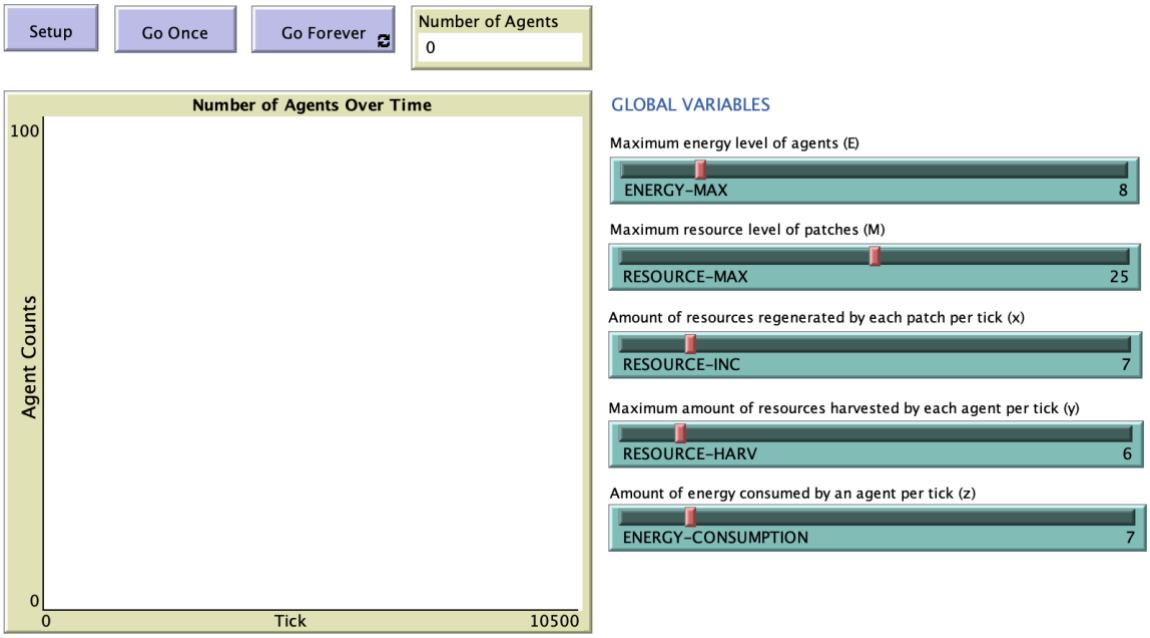
- Full surviving rate is possible.

Conclusion

- ENERGY-CONSUMPTION affects the survival rate of each agent as it defines the cost of movement at every tick.
- ENERGY-CONSUMPTION is special as it is the most sensitive global variable here, i.e., both increment and decrement impact the model heavily.
- Increasing ENERGY-CONSUMPTION has great negative impact, and vice versa, e.g.,



  - Decrement of 2 units (5 to 3) leads to 79 (+29) agents left after convergence



  - Increment of 2 units (5 to 7) leads to 0 (-50) agents left after convergence

- This is because increment in ENERGY-CONSUMPTION is likely to cause death as agents are unable to consume enough resources to sustain their lives; while decrement in ENERGY-CONSUMPTION reduces the cost of movement of each agent at every tick, which extends their lives, if not makes them live forever.

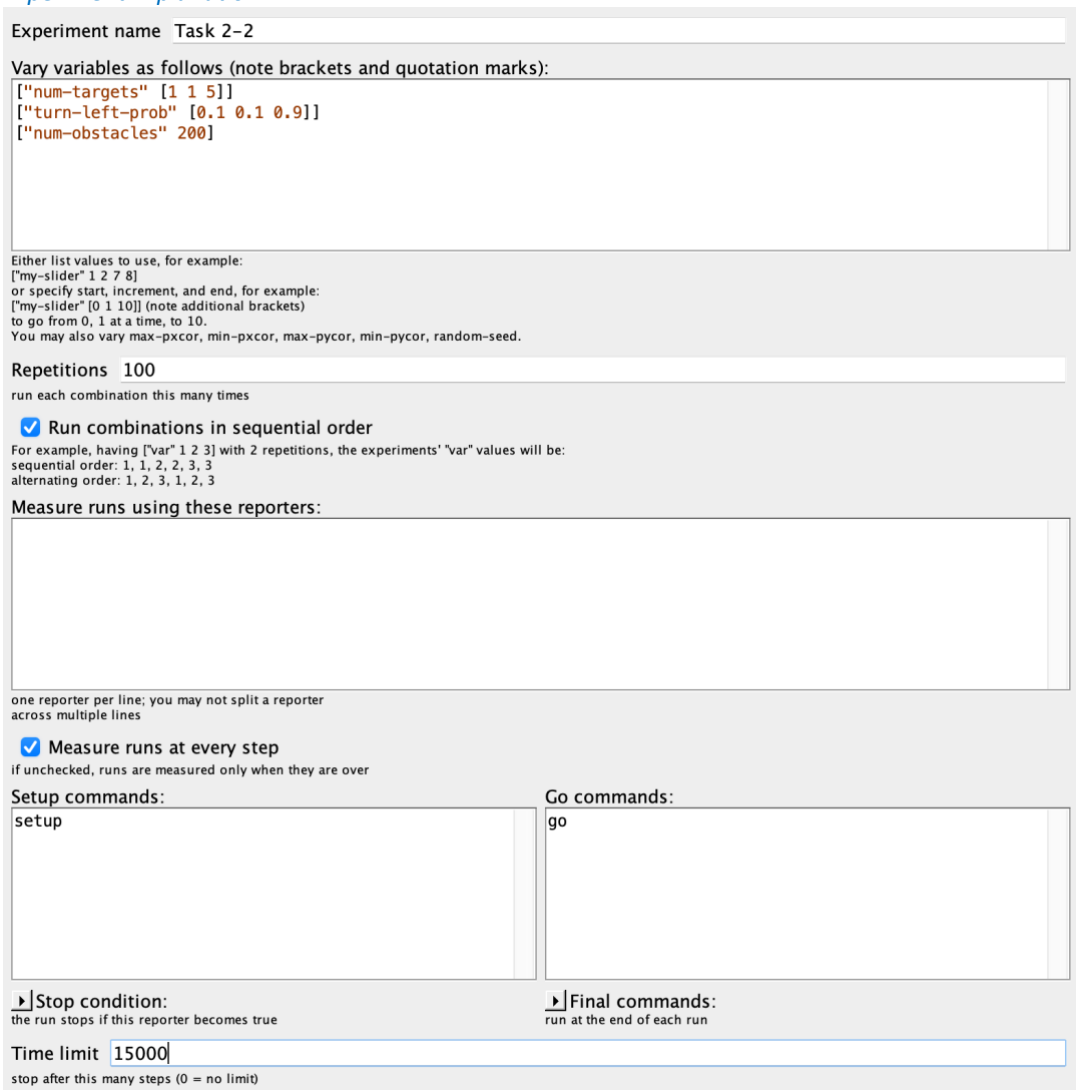
Task 2-2

An experiment is conducted using Netlogo's BehaviorSpace environment to observe the effect of the following factors:

- The number of targets
- The probability of turning left

on the time (ticks) it takes for an agent to reach a target.

Experiment Explanation



(Refer "cskang.2020@scis.smu.edu.sg_A1 /task-1/1-netlogo-intro-begin-improved.nlogo)

1. The number of targets is set to range of [1, 5], with increment interval of 1.
2. The probability of turning left is set to range of [0.1, 0.9], with increment interval of 0.1.
3. The number of obstacles is set to a constant value, 200.
4. "Repetitions" is set to run 100 simulations on this setting (*sufficient number of repetitions to ensure the conclusion is meaningful – as the average of 100 rounds will be used to draw the conclusion*).
5. "Time Limit" is set to 15,000 ticks to *ensure the simulation does not run to infinitely, as it should be reaching one of the targets by then*.

Visualization of Simulation Result

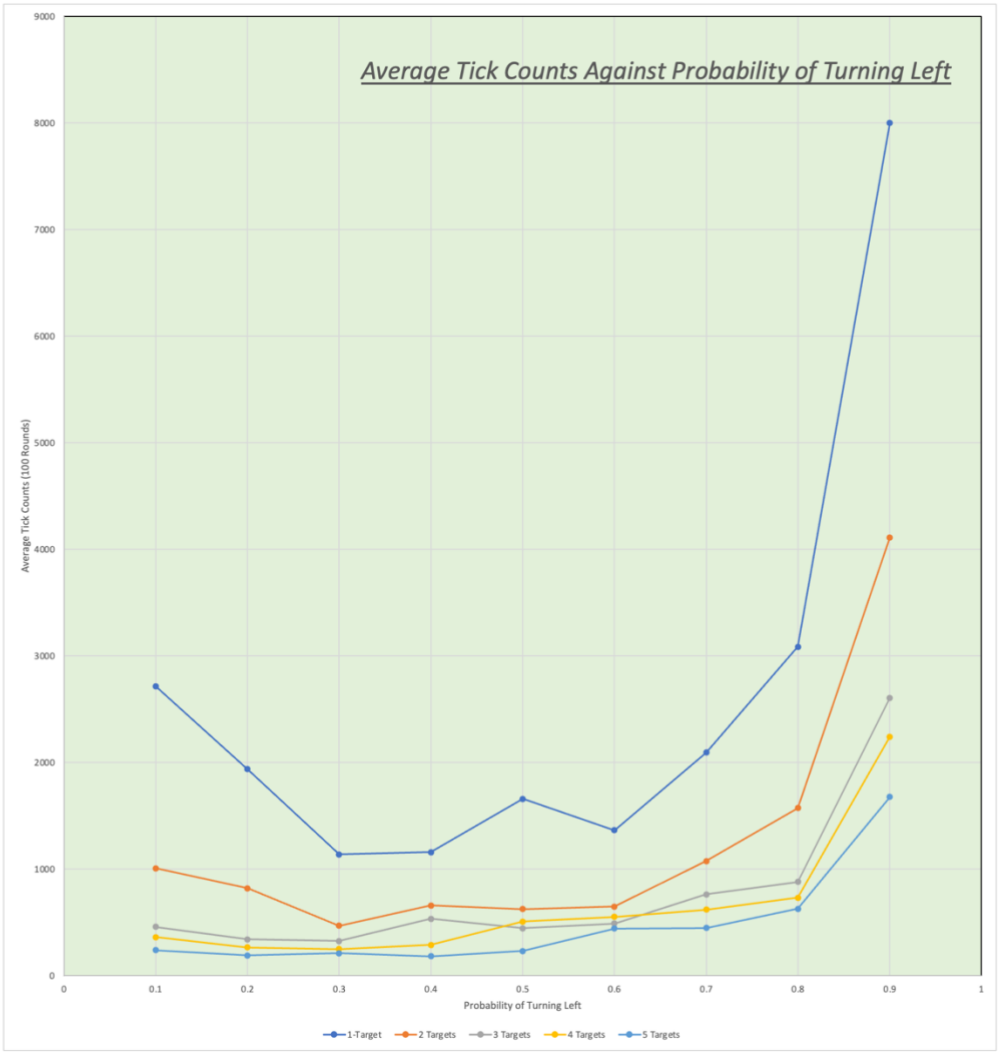
1 Target	
Turn Left Probability	Tick Counts (Avg of 100 rounds)
0.1	2716.86
0.2	1938.54
0.3	1138.66
0.4	1160.69
0.5	1660.37
0.6	1364.67
0.7	2093.23
0.8	3085.83
0.9	8000.97

2 Targets	
Turn Left Probability	Tick Counts (Avg of 100 rounds)
0.1	1009.81
0.2	821.55
0.3	470.14
0.4	661.11
0.5	626.56
0.6	648.61
0.7	1077.29
0.8	1573.57
0.9	4111.36

3 Targets	
Turn Left Probability	Tick Counts (Avg of 100 rounds)
0.1	458.21
0.2	342.06
0.3	326.11
0.4	533.94
0.5	445.74
0.6	490.56
0.7	764.07
0.8	880.04
0.9	2606.35

4 Targets	
Turn Left Probability	Tick Counts (Avg of 100 rounds)
0.1	362.98
0.2	267.35
0.3	250.61
0.4	290.52
0.5	509.68
0.6	552.11
0.7	619.5
0.8	731.42
0.9	2241.69

5 Targets	
Turn Left Probability	Tick Counts (Avg of 100 rounds)
0.1	241.81
0.2	190.96
0.3	211.63
0.4	182.14
0.5	231.61
0.6	443.3
0.7	448.46
0.8	627.52
0.9	1678.29



(Refer "cskang.2020@scis.smu.edu.sg_A1 /task-2/1-netlogo-intro-begin-improved Task 2-2-table.xlsx)

*Comment On the Impact of **Number of Targets** and **Probability of Turning Left** On the Time (Ticks) To Find A Target*

Number of Targets

- Based on the visualization above, increase in number of targets reduces the number of ticks to find a target.
- This is trivial as there are more alternatives to exit the program, and the agent is likely to reach a nearer target.

Probability of Turning Left

- Based on the visualization above, the probability of turning left within the range between 0.3 to 0.5 gives best results.
- Statistically, this aligns with theory as when the probability is 0.5, it is optimal for an agent to quickly switch direction to escape from obstacles (if necessary), hence results in fewer ticks required to find a target.
- As the computation has been introduced with certain degree of randomness, the optimal value here seems to be a little biased towards smaller values. This could be improved by ensuring a target is reachable, thus avoiding the outliers from infinite running model (currently the model will exit if tick counts hit 15,000).

End of Assignment 1